

Form Approved
OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)

3. DATES COVERED (From - To)

5a. CONTRACT NUMBER	
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5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER	
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5d. PROJECT NUMBER	
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5e. TASK NUMBER

5f. WORK UNIT NUMBER

8. PERFORMING ORGANIZATION REPORT

Air Force Research Laboratory (AFMC)
AFRL/PRS
5 Pollux Drive
Edwards AFB CA 93524-7048

10. SPONSOR/MONITOR'S ACRONYM(S)	
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11. SPONSOR/MONITOR'S NUMBER(S)	
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Approved for public release; distribution unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

20021021 062

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:

17. LIMITATION OF ABSTRACT

18. NUMBER OF PAGES

19a. NAME OF RESPONSIBLE PERSON

Leilani Richardson

a. REPORT

b. ABSTRACT

c. THIS PAGE

Unclassified

Unclassified

Unclassified

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19b. TELEPHONE NUMBER
(include area code)
(661) 275-5015

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

2 items enclosed = 210 + 213

④ Paper Rec'd After 30-day Deadline = { 22 days until Deadline }
FILE

MEMORANDUM FOR PRS (In-House Publication)

FROM: PROI (STINFO)

03 Sept 2002

SUBJECT: Authorization for Release of Technical Information, Control Number: **AFRL-PR-ED-VG-2002-213**
Shawn Phillips (PRSM), "AFRL POSS Applications Research" (viewgraphs)

POSS Nanotechnology Conference
(Huntington Beach, CA, 25-27 September 2002) (Deadline: 25 Sept 02)

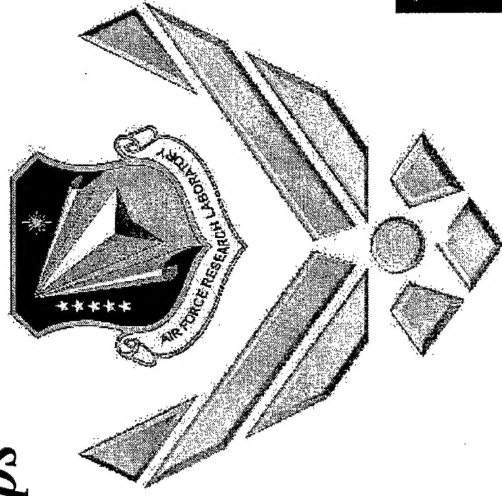
(Statement A)

AFRL POSS[®]

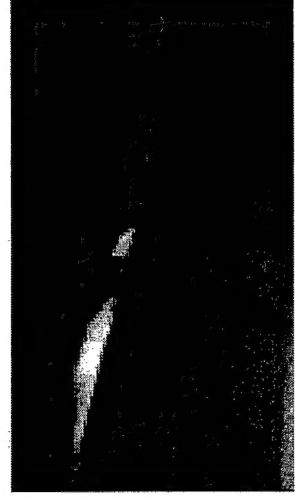
Applications Research

Dr. Shawn Phillips

Fundamental/Frontier
R&D

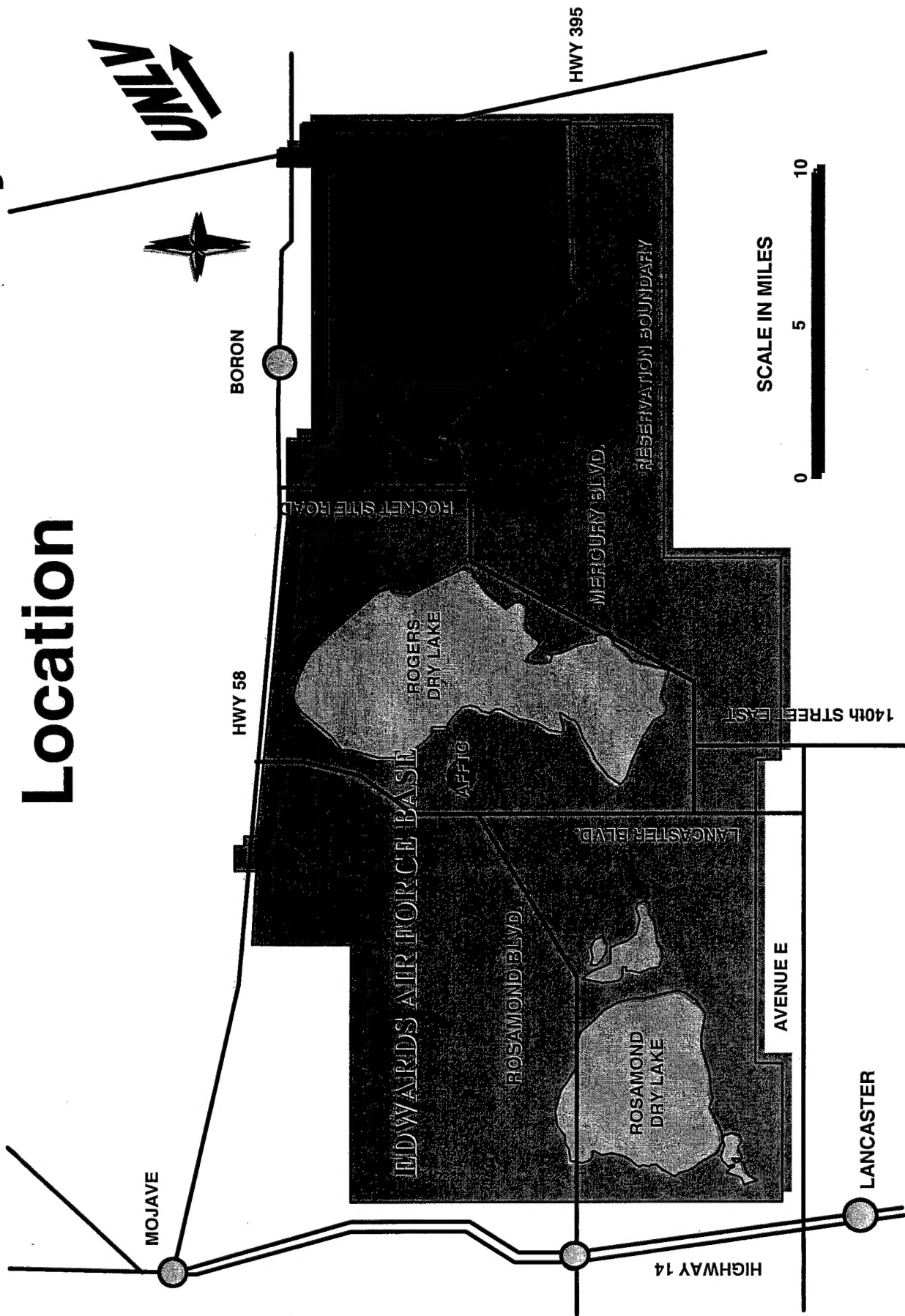


Applications
R&D



Technology
Transfer/Transition

Air Force Research Laboratory Location

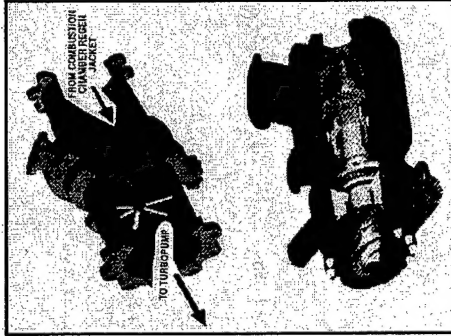


Air Force Research Laboratory Edwards AFB / Propulsion Directorate

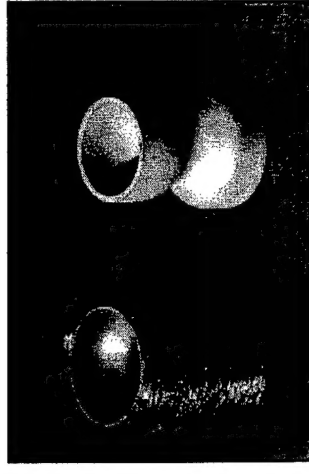
MISSION STATEMENT

Create and Transition
Propulsion and Power
Technology for Military
Dominance of Air and Space

(IHPRPT 2x)



IPD



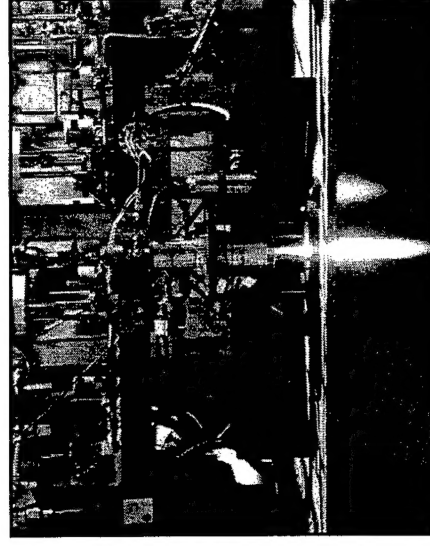
CARBON / CARBON



ESEX

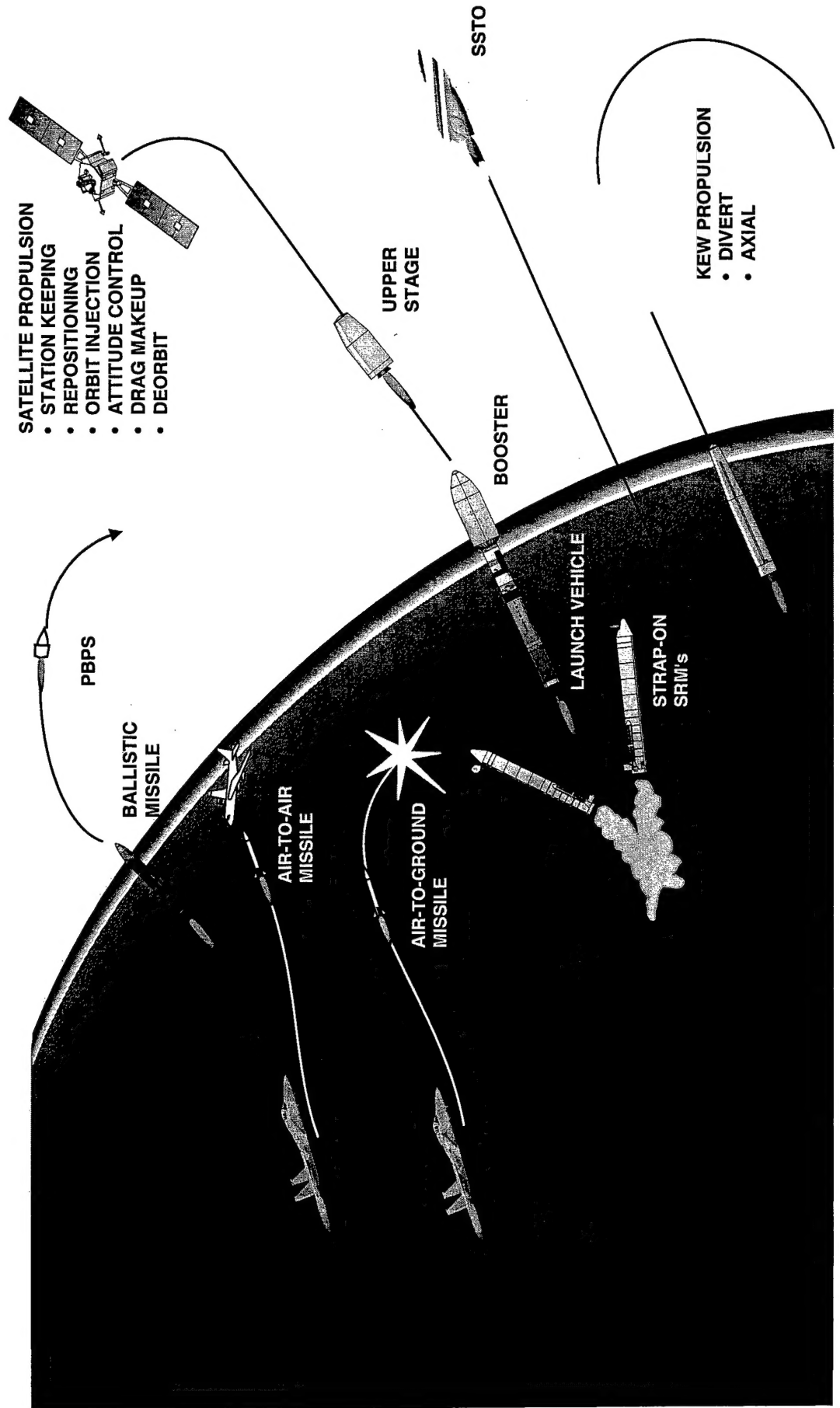


OTV



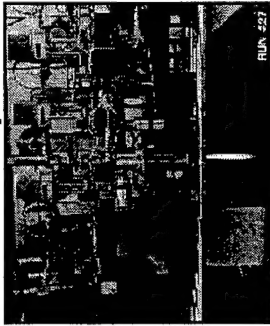
HEDM

Rocket Propulsion Technology Fundamental to all Space & Missile Systems



Edwards Research Site Propulsion Directorate

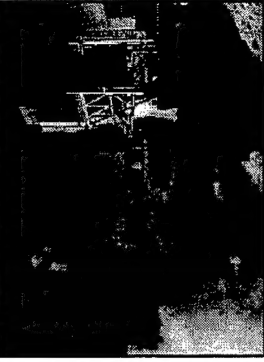
Satellite Propulsion



Experimental Systems



Large Systems Complex



Small Solid Components



TO 10,000,000 LB THRUST

FIXED OR SPUN

HORIZONTAL OR VERTICAL

ORIENTATION

ENVIRONMENTAL CONDITIONING

HIGH HAZARD

VEHICLE FLIGHT/HOVER TESTING

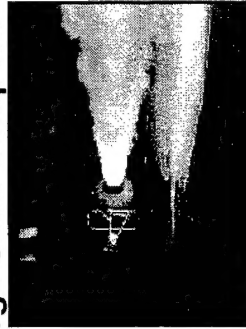
REDUCED SMOKE PROPULSION STUDIES

SOLAR THRUSTER EXPERIMENTS

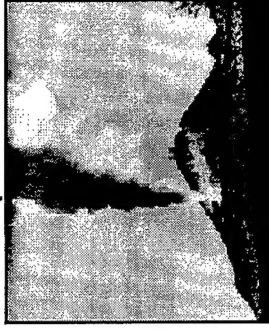
SATELLITE g LOAD STUDIES

TETHERED LAUNCH CAPABILITY

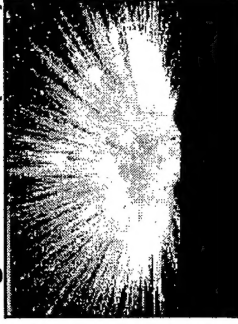
Large Solid Components



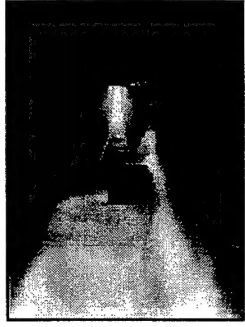
High Thrust (Solid and Liquid)



High Hazard (Solid)

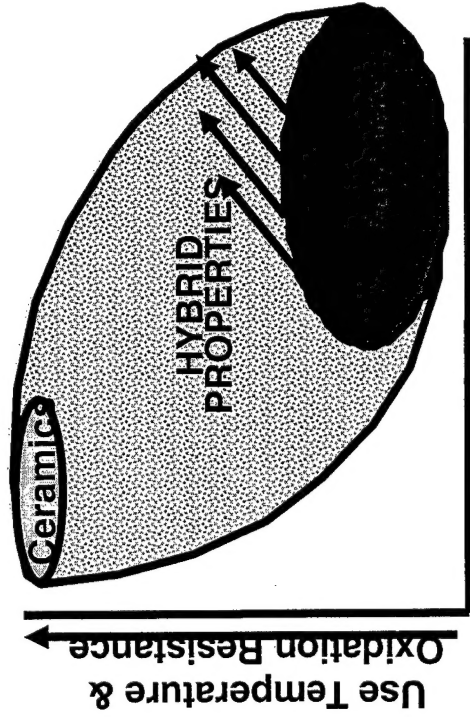


Large Liquid Components

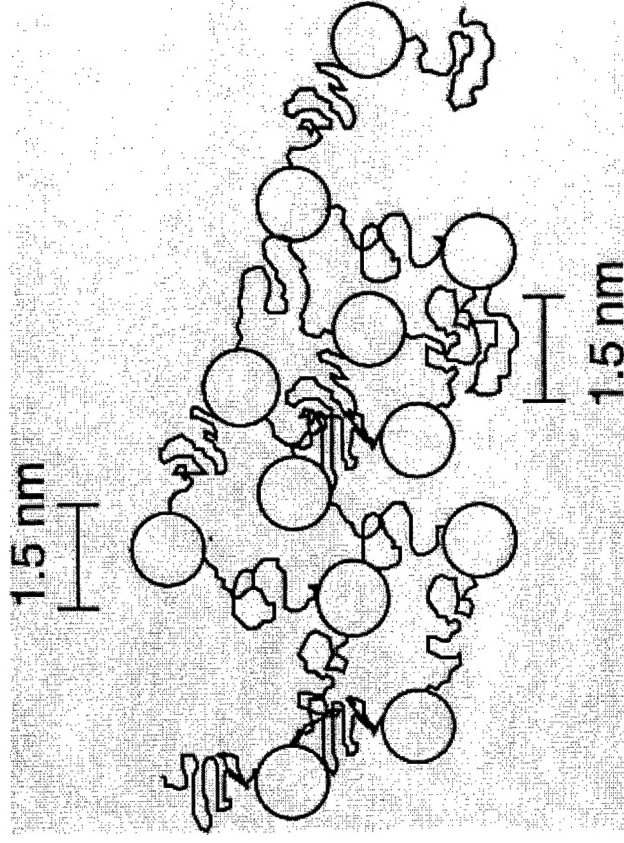


Key Aspects of POSS™ Technology

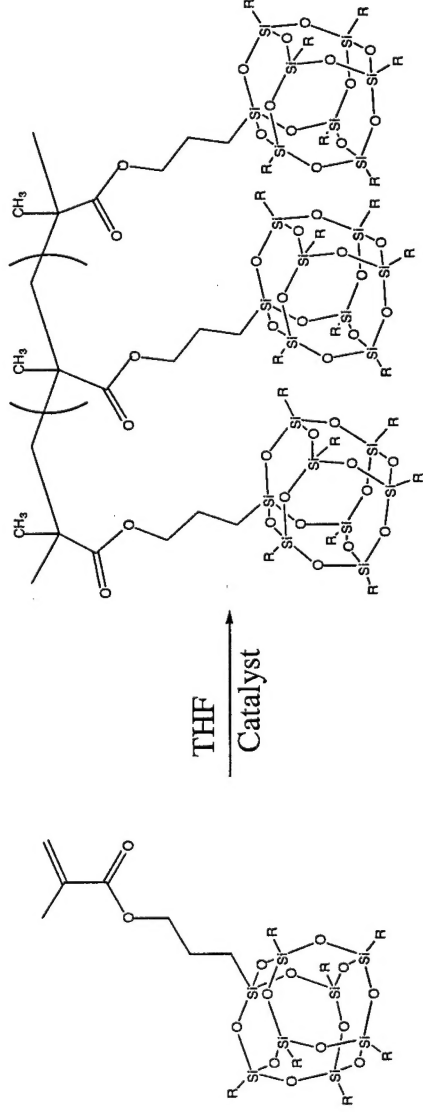
Hybrid (inorganic/organic) Composition



Nanostructured™ Chemical Reinforcement



POSS™ technology does not require manufacturers to retool or alter existing processes.



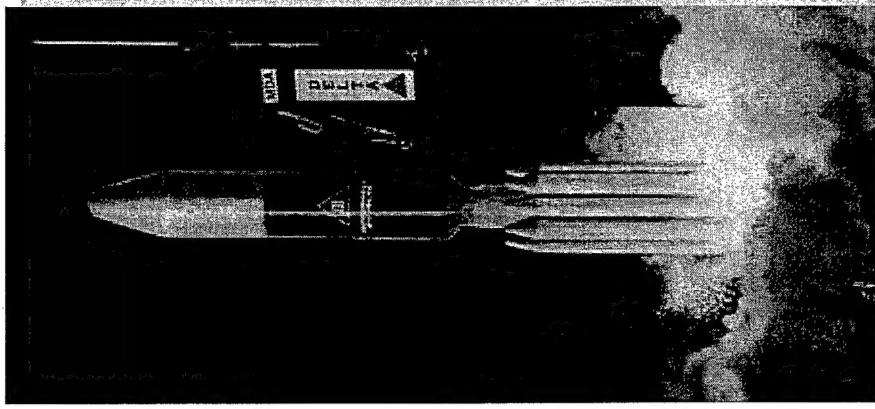
Lichtenhan et. al. *Macromolecules* **1993**, 26, 2141.
Lichtenhan, *Polym. Mater. Encyclopedia* **1996**, 10, 7768.

POSS[®] for Propulsion & Beyond

High-Performance Nanostructured Polymers

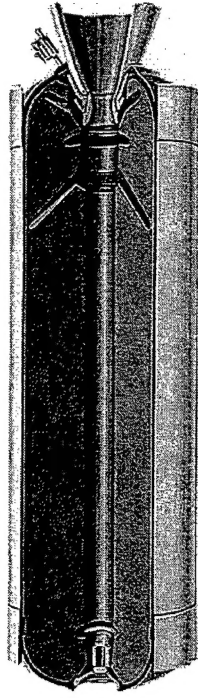
- High temperature case and motor insulation for solid rockets
- Plastic tubing and ducting for liquid rockets engines
- Space-survivable materials and coatings
- High-temperature canopies and hybrid lubricants

POSS Nanotechnology Offers Versatility!

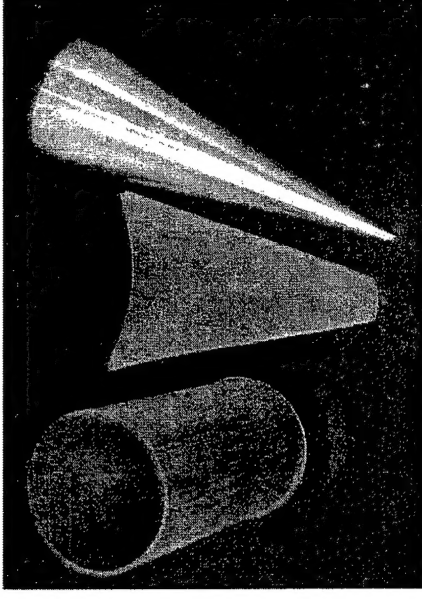


Solid Rocket Motor Insulation Program

Case Insulation



POSS-Insulation

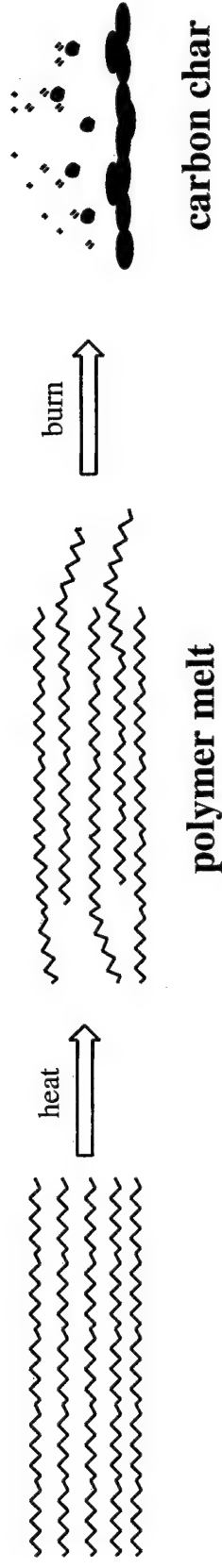


Why POSS?

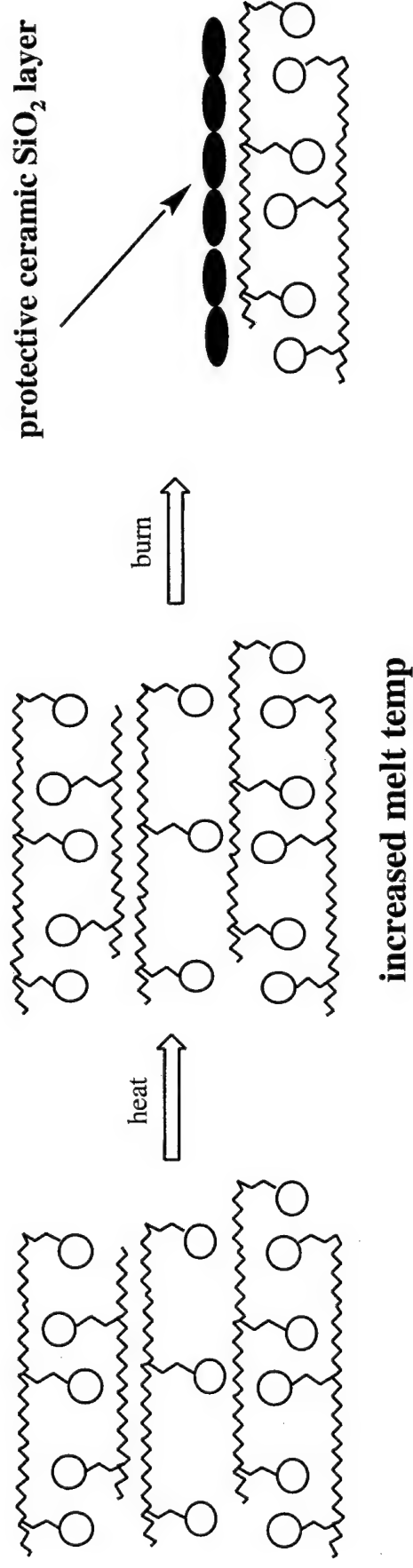
- need inorganic material with polymer flexibility
- ability to incorporate very high loadings
- processable using traditional equipment!!
- maintain mechanical property range
- physical cross-linker for TPEs

POSS for Ablative Materials

Traditional Polymer



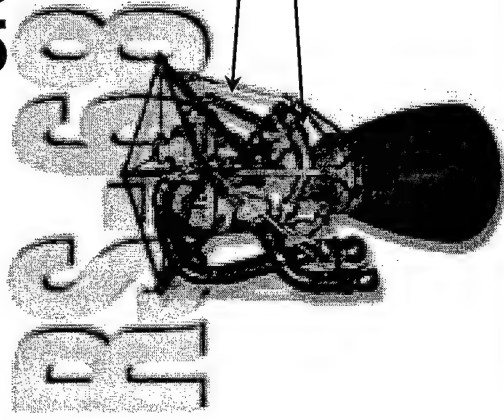
POSS Polymer



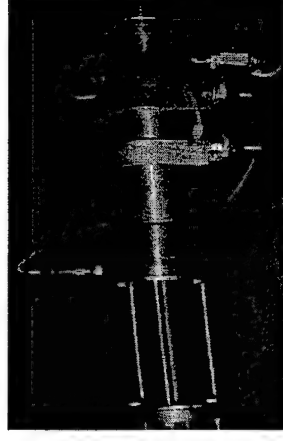
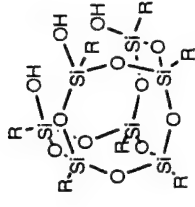
The Silicon to Oxygen ratio of 1:1.5 may be the key!!!

Liquid Rocket Engines

Crucial for Reducing Weight and Cost



Engine Ducting



*Polymer Tube/Case Hot Gas Burst
Tester*

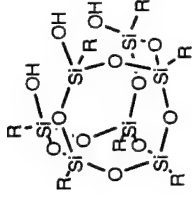
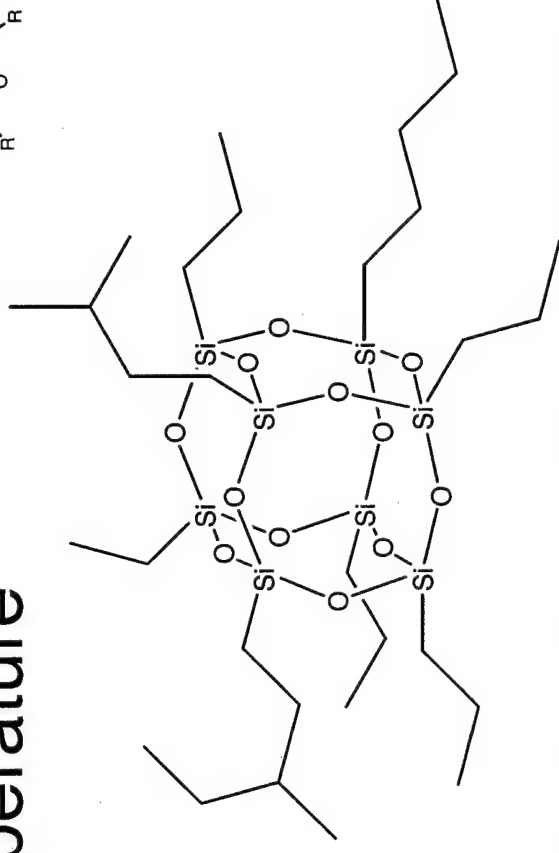
Why POSS?

- need to improve thermal & mechanical properties of SOTA polymers (PC, PPS, TPI, PEEK, PEI)
- Cornucopia of monomers for copolymerization reactions
- NO CTE mismatch (cryogenic capability)
- Potential for extrusion!

POSS Materials for Aerospace

High Temperature

Hybrid Lubricant Applications

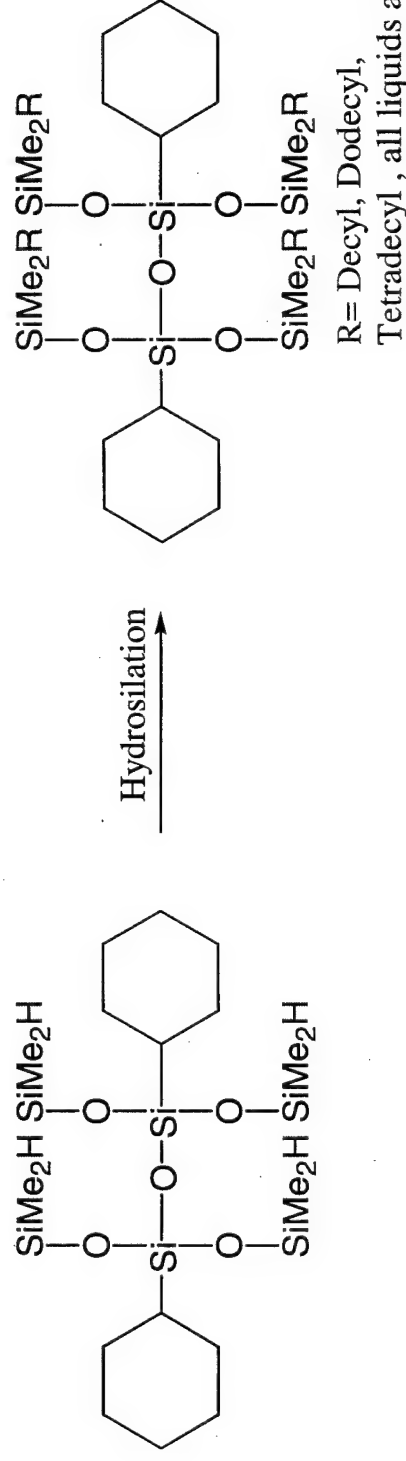


Why POSS?

- POSS based lubricants $T_{dec} = 590\text{ }^{\circ}\text{F}$
- Cornucopia of monomers for compatibility and viscosity control

Generation III Lubes

CyT₂ Class



When R=Decyl the viscosity at -40°F is 4000 cP

When R=Dodecyl, the freezing point is 10°F

Chemical and Physical Blending Studies Show that POSS follows the Rule of Mixtures

Joint Patent with Hybrid Plastics filed this year

Dual Use S&T: WMR

Jet Canopies



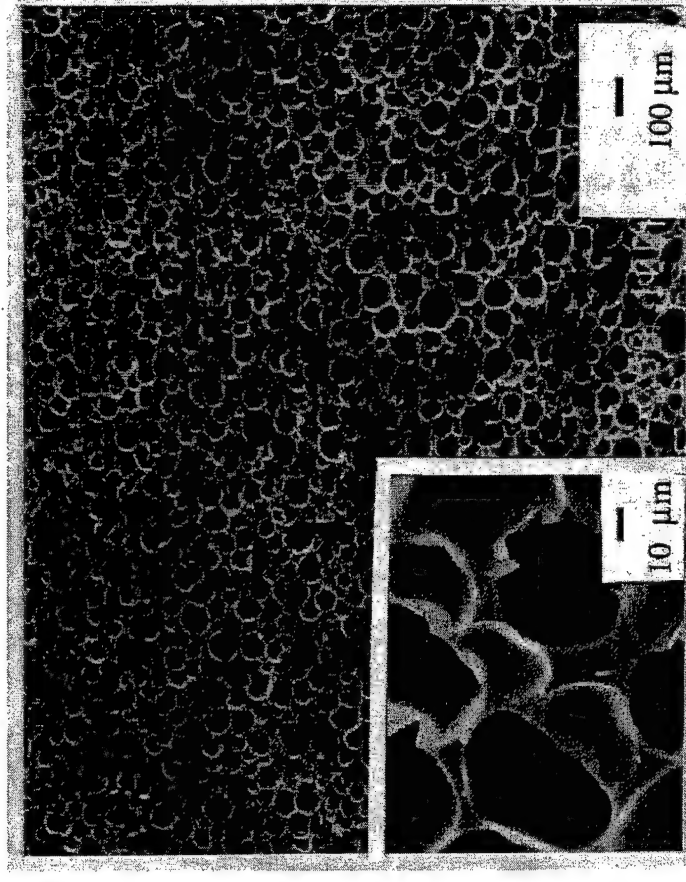
POSS-based Transparent Materials

- Mach 2x speeds limited for plastic canopy (need increased HDT)
- Target Engagement Times can be reduced by increasing flight speed

Why POSS?

POSS-PMMA increases use temp. up to 150 °C
POSS can be optically transparent!!
POSS-PMMA readily processed via foaming
Ability to make POSS-polycarbonates also

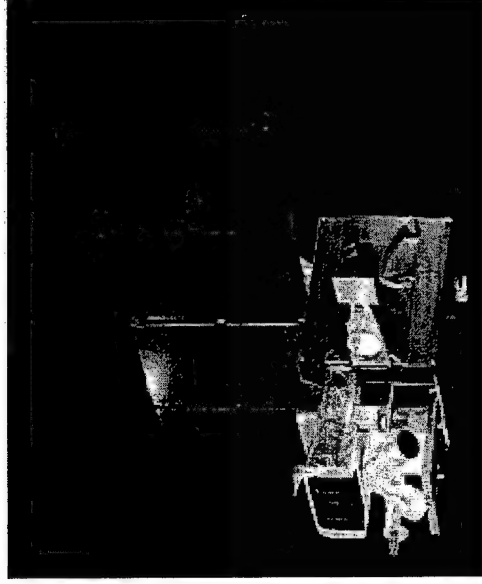
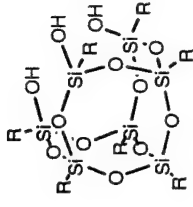
WMR's Current High
Performance Foam



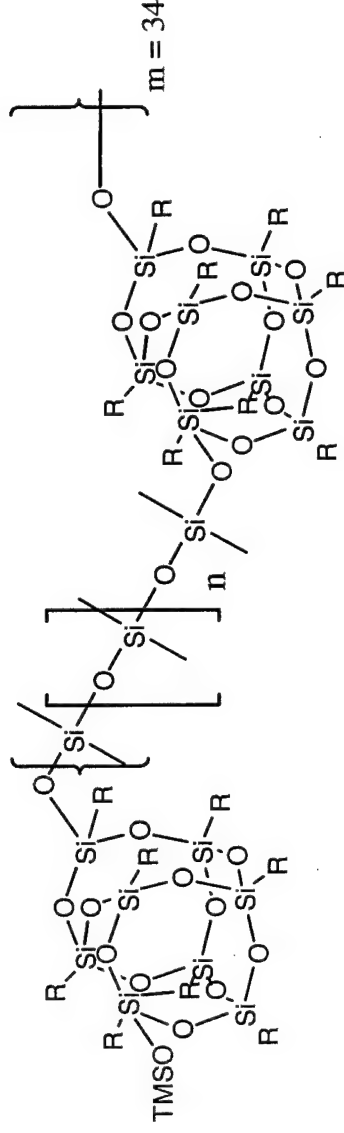
Cell Sizes can be Tailored
From Nano To Several mm

POSS Materials for Space

Critical for Increasing Lifetime



Satellites & Space Systems



POSS-PDMS copolymers

POSS Nanocomposite Payoffs

- Maximum Space Survivability
 - LEO, AO, VUV, Impact
- Lower Density 'Filler'
- High Modulus
- Resins for all Structural Applications

Simulated 3 mo. AO/VUV Exposure

- 9-20x greater AO resistance than current state of art
- Even better AO/VUV resistance
- Current NASA, Aerospace Corp., and University collaborations

Where Are We Now?

Research:

New Monomers & Feedstocks (>180) - simplicity
Control & Prediction of Property Enhancements

Production:

Multi-Ton Production Capability!!

10-100x Reduction in Cost (monomer dependent)!!!

Application:

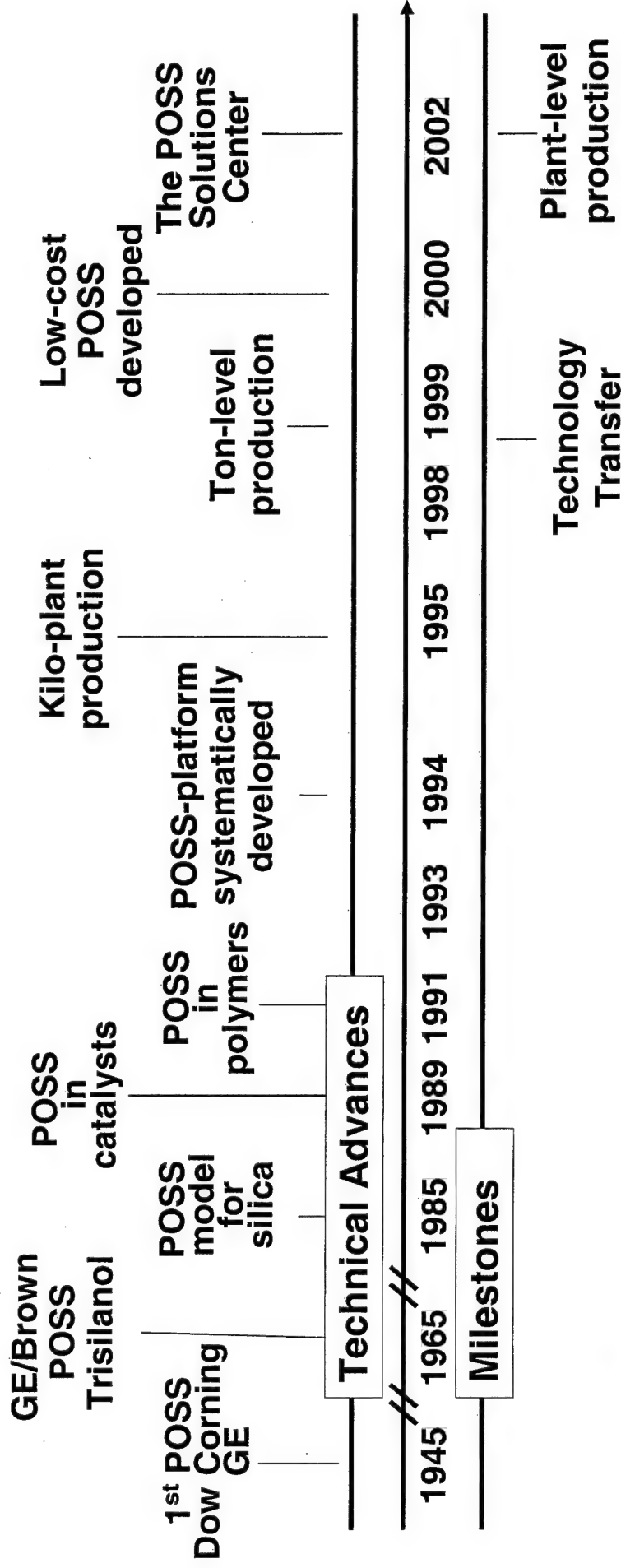
Critical & High-Risk Paths for Air Force Applications

(Insulation, Ducting, Lubricants, Space Materials)

Incorporation and R&D Testing by Numerous Companies

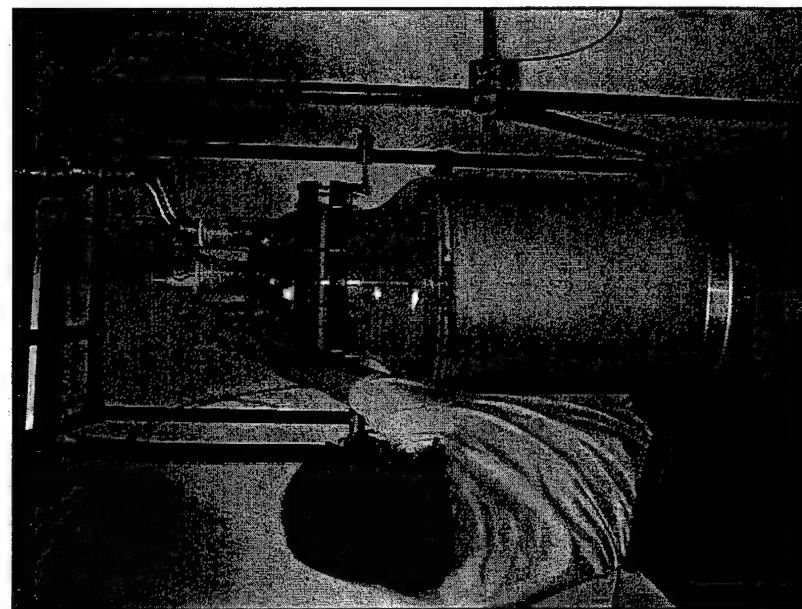


POSS™-Technology Timeline

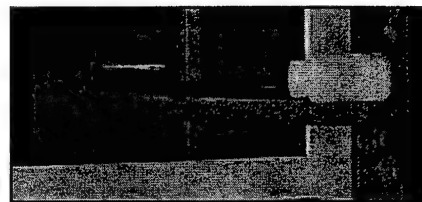


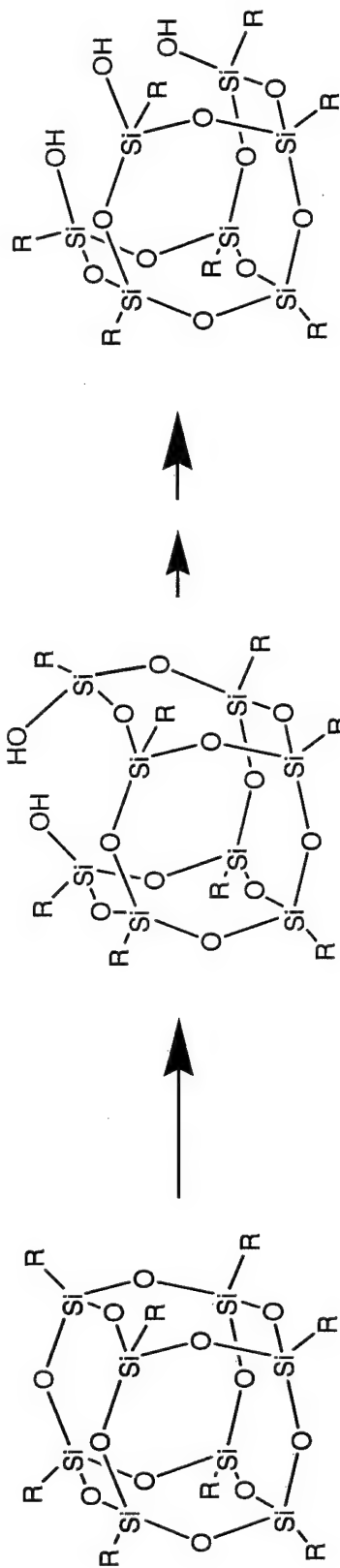
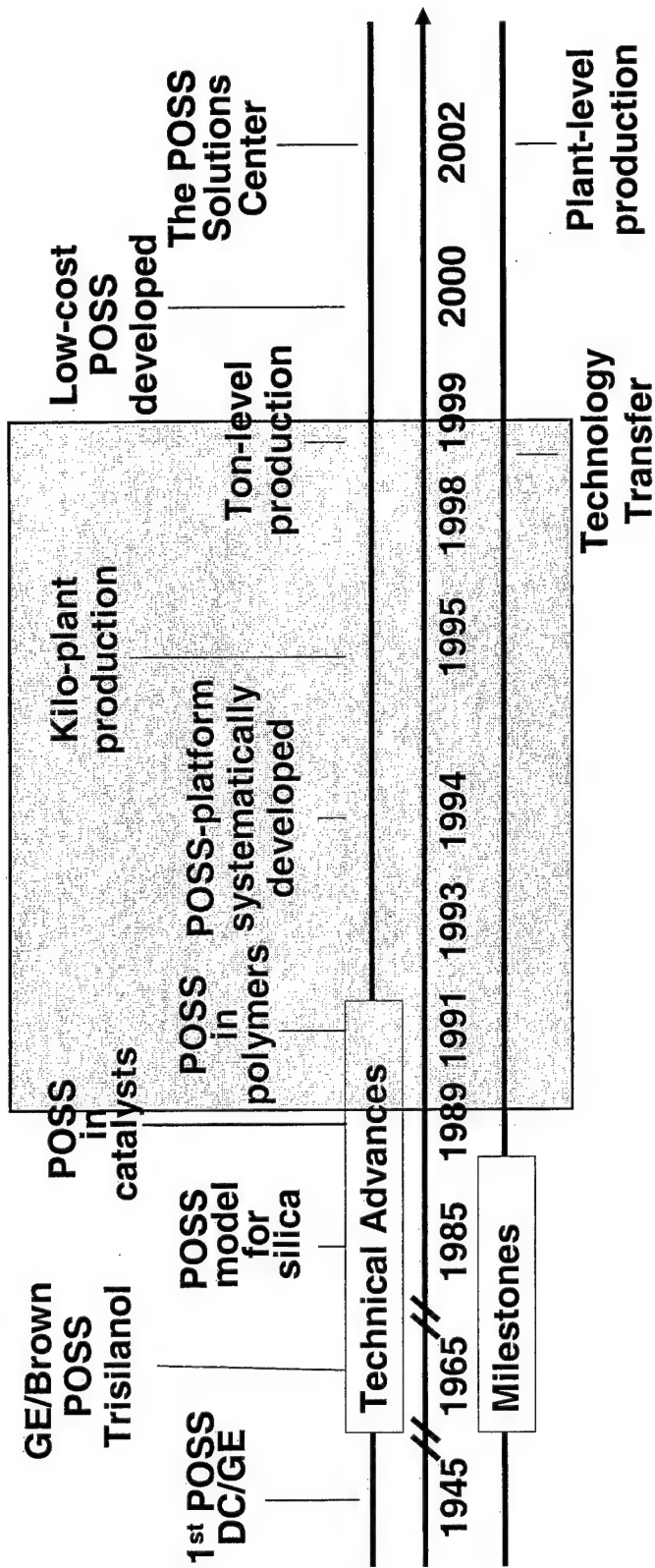
UCL Air Force Hybrid Plastics

Chemistry Polymers Commercial Solutions

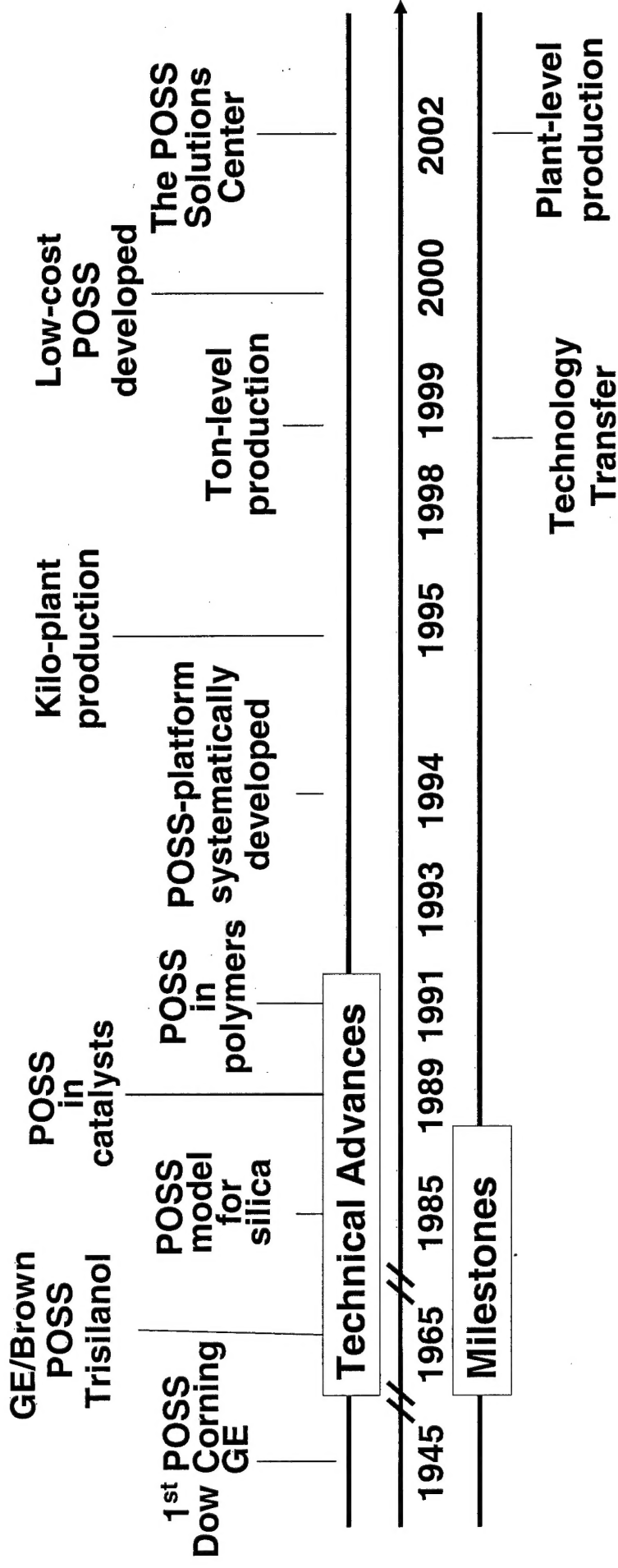


Reverse Scale-up?





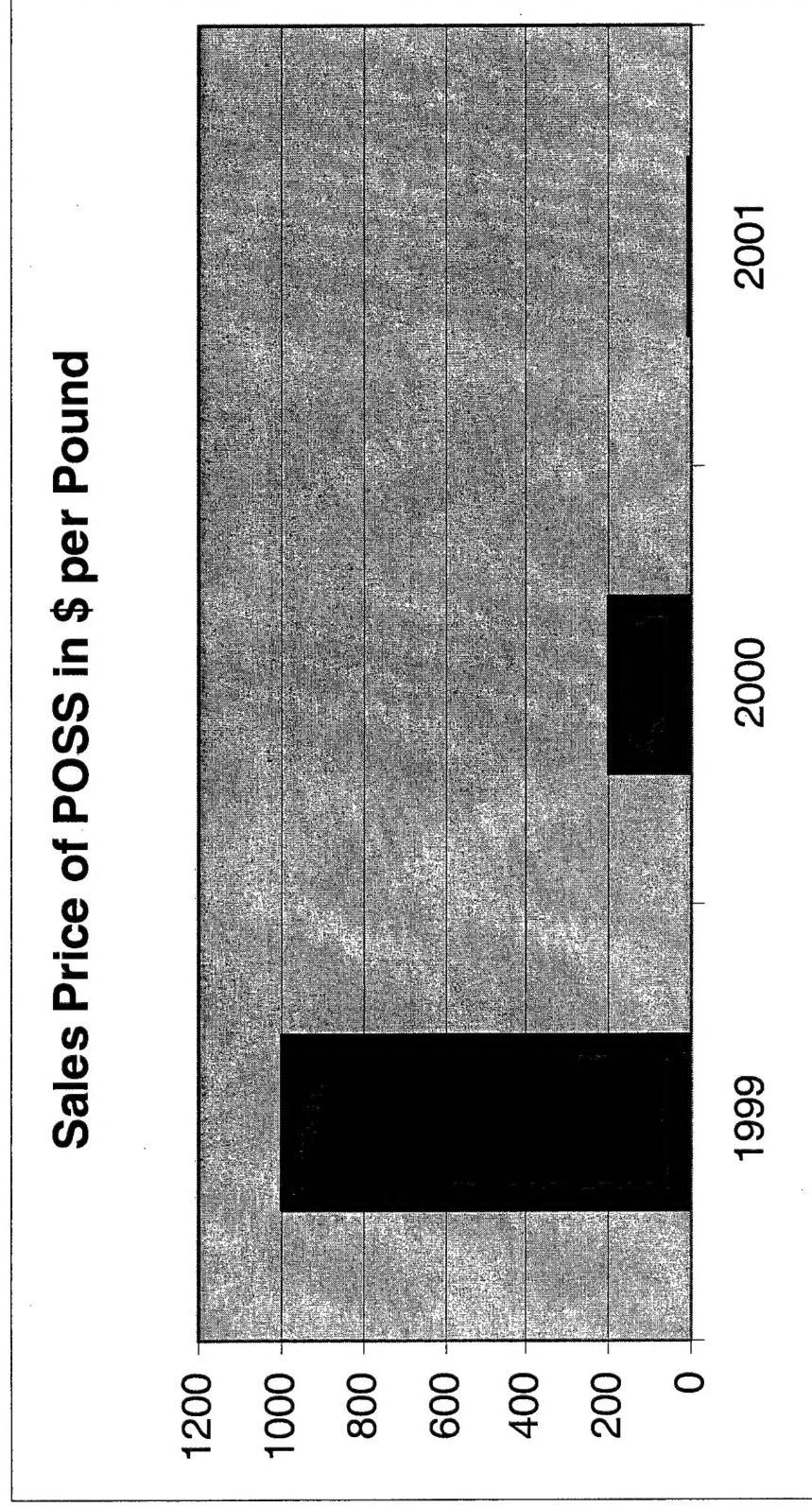
POSS™-Technology Timeline

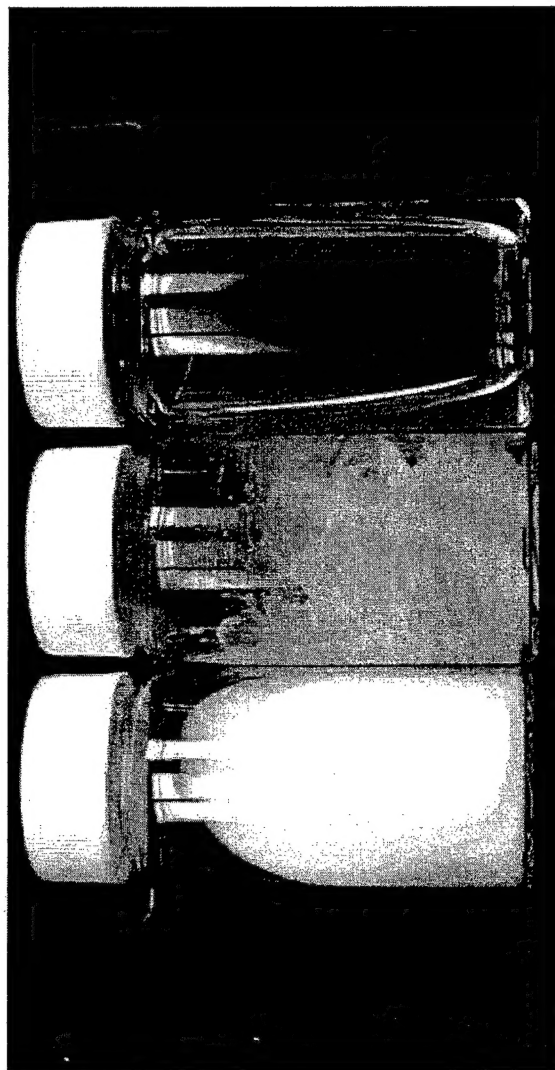
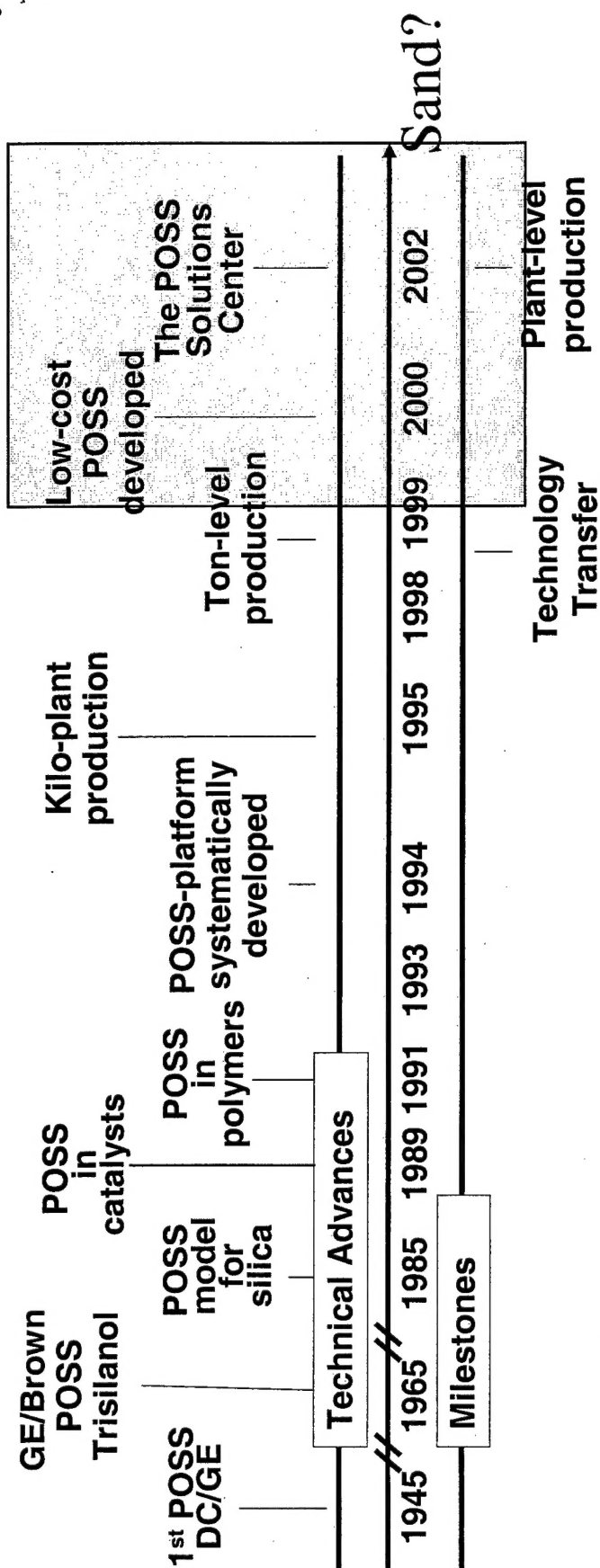


UCL Air Force Hybrid Plastics

Chemistry Polymers Commercial Solutions

ATP Funded Cost Reduction





Crystalline Solids

Wide melting range 24°C to 400°C+

Waxes

Wide viscosity range 40cSt. to 400cSt

Liquids & Oils

Summary

The Air Force is heavily invested in POSS Applications Research and Development

Currently one application is being 'flight-tested' for a technology transition

New applications are being investigated (e.g., batteries, capacitors, radomes)

The technology transfer to Hybrid Plastics **IS** a success story with significant volume increase and price reduction

POSS Nanotechnology Offers Versatility!!